ENGL 015

Assignment 5

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Audience: BIOL 110 teachers and students

**RNA World Hypothesis**

What is the origin of life? What was the first form of life to exist? As the number of people accepting the theory of evolution began to increase, question similar to these began challenging believers all around the world. After several studies and extensive experimentations, the majority of scientists agree that the first form of life to exist was an RNA molecule. The grand discovery led to what is now called the RNA World hypothesis.

In 1859, an English naturalist named Charles Darwin published a work of scientific literature that altered the way man-kind viewed life. Darwin’s book, *The Origin of Species*, launched the scientific theory that populations evolve over the course of generations through several processes and techniques. Evolution development comes about through natural selection, mutation, genetic drift, and gene flow. Natural selection is a nonrandom process in which the frequency of certain biological traits fluctuate depending on fitness, thus organisms that are best suited for their environment are able to pass their genetic traits to preceding generations. Mutations are changes in genetic sequences. Genetic drift is a change of gene variations due to random sampling. Gene flow is the process by which genes are transferred from one generation to another.

The second Darwinian claim explains how the diversity observed in several species, domains, and kingdoms arose from a common ancestor. Darwin believed that all of the species observed on earth, are in one way or another related. "There is a grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one". (Darwin 490) They claimed that a common ancestor lived almost 3.9 billion years ago. However, the identity of this common ancestor remains a mystery. Till this day, there is no single agreement among the scientist on the identity of the first organism. Some scientists believe the first organisms were amoebae, which is any of several tiny, one-celled protozoa in the phylum Sarcodina. Amoebas live in freshwater and salt water, in soil, and as parasites in moist body parts of animals. Another majority of scientists believe that fungi were the first organisms. Fungus is a member of a large group of eukaryotic organisms that includes microorganisms such as yeasts and molds. Finally, the remaining scientists believe that bacteria occupied earth before any other organism. Bacteria are microscopic organisms whose single cells have neither a membrane-enclosed nucleus nor other membrane-enclosed organelles like mitochondria and chloroplasts.

The oldest known fossils date back 3.5 billion years. They fossils contain cyanobacteria microbes. Some scientists say that there's an even older first organism that was the ancestor common to both eurkaryotes and prokaryotes. But they disagree on whether that ancestor evolved first into the former and then the latter, or vice versa. However, scientist realized that trying to figure the first organism would be very difficult if there was not another technique. Thus a new approach was adapted in which they will attempt to identify the components of the first organism instead. Again, disagreement took charge. Scientists split between those who believe that the first organism was not complicated and did not have complex nuclei; as a result, the first organism must have been a prokaryote. The other minority believed that it was the complexity of the nuclei that actually gave rise to the rest of the cell; as a result, the first organism must have been a eukaryote. Since the majority believed that prokaryotes were the first single celled organisms, it was agreed that prokaryotes gave rise to eukaryotes.

Although the majority of scientists believed it was prokaryotes that existed first, the phylogeny indicates that bacteria were the first organism that the LUCA (last universal common ancestor) evolved to afterwards. After the category of candidates were narrowed, it was time to identify what gave rise to those cells. After several studies, it was identified that the nucleoid was the first micro-organelle to compose the first prokaryotic cell. (Gregory) That was how the study of genetics became related to evolution and this was the start of the wide belief that certain genetic materials were the first molecules on earth.

Scientists were able predict a phylogenetic tree of life based on rRNA. The tree of life was constructed based on several observations and on critical examinations, but only deductions and predictions define the identity of the common ancestor or the LUCA. Indeed, several gaps in the tree of life have not been filled yet and an agreement on a single common ancestor was not reached. In 2009, John Sutherland and his colleagues from the University of Manchester, UK, created a ribonucleotide, a building block of RNA, from simple chemicals under conditions that may have existed on the early Earth, concluding that the origin of life might have actually originated from molecules of RNA. (The Medical News) As a result, RNA became the earliest self-replicating molecule known to mankind.

RNA, ribonucleic acid, is a molecule that consists of a long chain of nucleotide units. Its units consists of a nitrogenous base, a ribose sugar, and a phosphate group. RNA comes in a variety of shapes and forms and is very similar to DNA, but differs in a few important structural details. RNA is usually single-stranded, contains a ribose sugar (which lacks an oxygen atom when compared to DNA’s sugar), and has the base uracil rather than thymine that is present in DNA. RNA is transcribed from DNA during cell division and protein formation. It carries the structural genetic information which is found in the DNA. There are four main types of RNA which are: mRNA, rRNA, tRNA, and ncRNA. Finally, few organisms and viruses use RNA instead of DNA as their genetic material. (Atkins, Gesteland, and Cech)

The phrase "RNA World" was first used by Nobel laureate Walter Gilbert in 1986 as an observation of the catalytic properties of various forms of RNA. However, the concept that RNA could have various forms was accepted among scholars ever since the 1960’s when the molecular biologist Alexander Rich explained a similar idea in a published article. (Lindhal) The RNA World is a theory relating to the origin of life in which RNA carried out both the information-storage function and the catalytic function of replicating that information. These roles are now performed by DNA and proteins, which did not exist back then. As mentioned earlier, a ribose is a sugar molecule found within the RNA, it was discovered that its function is to catalyze RNA molecules. An RNA replicase ribozyme is a catalytic RNA molecule capable of self-replicating. No such molecule complies with these standards; however, an RNA molecule is capable of copying up to 20 nucleotides of just about any RNA sequence it encounters.

RNA was capable of surviving on its own. RNA is capable of storing clear information, act as an enzyme, act as a regulator, and even function as a catalyst. It was impossible for RNA to be a perfect molecule that would store information because simple forms of energy was able to damage to mutate and even damage fragments of the RNA. While this may seem to be a bad case in today’s life, conditions were very different in a much more primitive life that previously existed. Although these limitations compromised its existence, RNA had enough support to be a possible candidate as the origin of life.

According to the theory, the last common ancestor was RNA-based and evolved RNA viruses. Some of the viruses evolved into DNA viruses to protect their genes from attack. Through the process of viral infection into hosts, the three domains of life evolved. The concept originated through thermosynthesis. Thermosynthesis suggests that free energy drives anabolic reactions. When the concept of thermosynthesis is combined with the RNA World hypothesis, the resulting overall origin of life model suggests new explanations for the emergence of the genetic code and the ribosome. It is proposed that the first protein obtained the energy to support the RNA World by a thermal variation. It is further proposed that this first protein, named pF(1), was the single translation product during the emergence of the genetic machinery. During thermal cycling, pF(1) condensed many substrates with broad specificity, yielding randomly constituted protein and RNA libraries that contained self-replicating RNA. The smallness of pF(1) permitted the emergence of the genetic machinery by selection of RNA that increased the fraction of pF(1)s in the protein library, which led to the formation of rRNA, tRNA, and mRNA. (Muller)

In 2011, Thomas Čech, a Nobel Laureate in chemistry, suggested that multiple self-replicating molecular systems preceded RNA. Proteins large enough to self-fold and self-assemble emerged only after RNA was available to catalyze peptide ligation or amino acid polymerization. Although amino acids and short peptides were present in the earlier mixtures, there is no proof whether they existed along with the first pF(1) protein. Čech proposed that the RNA World evolved from ribosomes and such similar structures before giving rise to DNA, RNA, and proteins. The RNA world hypothesis suggests that RNA in modern cells is an evolutionary remnant of the RNA world that preceded ours. Which results in the most important conclusion: modern RNA is not the same RNA that existed billions of years ago.

One of the greatest questions to ever puzzle mankind is finally being answered. Yes, there are few speculations but this is common for such a new discovery. The RNA World hypothesis, if true, could change man’s understanding of life and the whole process of evolution. The whole definition of RNA will be altered as well. RNA was thought to be a simple aid to DNA for the process of synthesizing protein, however it seems like there is much to be learned at what could be defining our lives in the future.

In the end, this shows that scientists are getting closer to identifying the secrets of the origins of life. Scientists at the Scripps Research Institute have synthesized for the first time RNA enzymes that can replicate themselves without the help of any proteins or other cellular components, and the process proceeds indefinitely (Sauter). They indeed have created life. This was marked as one of the greatest achievements of man-kind. But so what? Supposedly RNA was truly the first form of life to exist, what was it that gave it this life?

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